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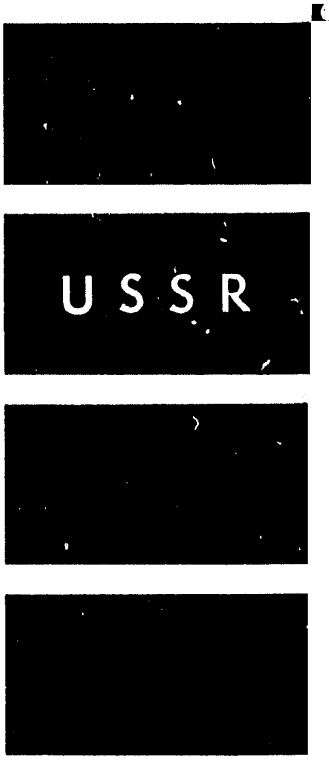

TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY

BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 12/79)

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TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY

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AGROTECHNOLOGY

NUTRIENT YEASTS FROM WOOD HYDROLYSATES AND WEAKLY DECOMPOSED PEAT

Moscow, LES--SEL'SKOMU KHOZYAYSTVU (PROIZVODSTVO I PRIMENENIYE PRODUKTOV PERERABOTKI DREVESNYKH OTKHODOV) in Russian 1978 signed to press 6 Mar 78 pp 133-151

[Chapter 6 from the book "Les--Sel'skomu Khozyaystvu (Proizvodstvo i Primeneniye Produktov Pererabotki Drevesnykh Otkhodov)" (The Forest--For Agriculture (Production and Utilization of Woodworking Byproducts in Agriculture)) edited by A. Ya. Kalnin'sh, Izdatel'stvo "Lesnaya Promyshlennost'", 2,500 copies, 192 pages]

[Text] 6.1 Effectiveness of the Use of Nutrient Yeast in the National Economy

There can be no doubt that we must develop production of protein-vitamin yeast if we are to reinforce the feed base of animal husbandry. But the national economy's demand for yeast still significantly exceeds the potential for satisfying this demand.

As we know, nutrient yeast is produced in our country by enterprises of microbiological, pulp and paper, and food industry.

Hydrolysis industry (3) is the best prepared for practical solution of the problem of supplying nutrient protein and vitamins to animal husbandry in the Soviet Union. A number of improvements have been made in recent years in the procedures and apparatus of hydrolysis operations. This has led to significant improvements in the principal technical-economic indices of hydrolysis plants, and labor productivity has risen at many of them.

But some significant theoretical questions are still insufficiently resolved, in particular: Assimilation of carbon-containing and other sources of nutrition, yeast respiration, and the associated problem of processing undiluted hydrolysates. Obviously, by resolving these questions we can put the internal reserves of yeast production to use.

Nutrient yeast is an effective protein-vitamin concentrate. It contains readily assimilable protein supplying all of the essential amino acids, and valuable vitamins, enzymes, and hormones that improve metabolism in the animal body.

Proteins, or the amino acids making them up, are the most expensive and least available part of the animal's food ration. We know that the nutritional value of protein depends not only on presence of essential amino acids but also their ratio. If this ratio corresponds to the needs of the organism, a relatively small quantity of amino acids would have to be introduced into the ration to ensure the organism's normal vital activities. It has now been demonstrated that consumption of foods in which the amino acid ratio is extremely wrong, and consequently their nutritional value is low, may have a harmful effect on the body, since this creates a negative nitrogen balance within it (8).

A comparison of the relative content of amino acids in different yeasts (25) with the amino acid content of whole chicken eggs would show that the best amino acid ratio, one coming close to that recommended by an FAO standard, is possessed by osmophilic yeast grown in more-concentrated media, and nutrient *Candida tropicalis* (Table 6.1).

Table 6.1 Relative Amino Acid Content in Different Yeasts

(1) Аминокислоты	Содержание незаменимых аминокислот (по отношению к триптофану) (2)					
	(3) в цельном яйце	(4) по стандарту ФАО	(5) в дрожжах			
			(6) осмофильных	(7) хлебопекарных	(8) пивных	(9) кормовых
Триптофан (10)	1,0	1,0	1,0	1,0	1,0	1,0
Лизин (11)	4,8	3,0	4,4	15,0	45,8	1,6
Треонин (12)	3,3	2,0	2,75	5,6	28,5	0,88
Метионин (13)	2,7	3,0	0,40	1,0	3,8	0,05
Валин (14)	4,9	2,8	2,7	10,2	30,1	0,80
Фенилаланин (15)	4,2	4,0	1,9	6,5	23,2	0,6
Лейцин + изолейцин (16)	16,8	6,4	7,1	24,0	77,7	1,3

Key:

1. Amino acids
2. Essential amino acid content (in relation to tryptophan)
3. In whole eggs
4. FAO standard
5. In yeasts
6. Osmophilic
7. Baker's
8. Brewer's
9. Nutrient
10. Tryptophan
11. Lysine
12. Threonine
13. Methionine
14. Valine
15. Phenylalanine
16. Leucine + isoleucine

They are several times superior to concentrated feed of plant and animal origin in relation to vitamin content.

Yeasts contain (mg/kg):

B_1 (thiamine)	5-20
B_2 (riboflavin)	40-130
B_3 (pantothenic acid)	40-140
B_4 (choline)	2500-6000
B_5 (nicotinic acid)	350-600
B_6 (pyridoxine)	10-20
B_7 (biotin)	0.6-2.3
B_8 (inositol)	1500-4000
Ergosterol (provitamin D)	200-5000

The feed value of yeasts is intensified by their ash fraction, which contains the following macroelements (percent):

P	1.5-3.5	K	1-3
Ca	0.1-1.5	Na	0.04-0.4

and microelements (mg-percent):

Fe	10-300	Cu	0.6-40
Mn	1-26	Zn	2-17
Co	0.02-2		

The composition of yeasts also includes (percent): Lipids--2, cellulose--0.5, and nitrogen-free extracts--39, the latter being 18 percent carbohydrates (7).

Scientific research and the practical experience of animal farms have shown that addition of yeast to animal and bird feed increases productivity and improves the quality of animal products (11). Introduction of yeast into the feed ration of young animals accelerates growth, improves viability, reduces epizooty, and improves development of young animals. Addition of yeast to the feed of animals, birds, and fur-bearing animals also increases the effectiveness with which conventional feeds are utilized, it reduces their consumption per unit of production by 10-20 percent, and it compensates for some of the lacking feed of animal origin.

Given the present feed consumption level per unit production, use of 1 ton of yeast would make it possible to obtain an additional 700 kg of pork (live weight) in pig breeding, and about 2 tons of additional meat or 15,000 eggs in poultry breeding (17).

6.2 Hydrolysis of Plant Tissue

Use of plant raw material for microbiological protein synthesis requires hydrolysis of a complicated complex of biopolymers contained within plant tissue. Catalysts are used to accelerate hydrolysis. Mineral acids such as, for example, sulfuric and hydrochloric are the most active catalysts.

Hydrolysis can be performed with low concentrations (0.5-5 percent) of aqueous acid solutions, or with concentrated acids.

Hydrolysis is performed with diluted acids at 175-190°C and at pressures corresponding to these temperatures.

The acid concentration is 0.4-0.6 percent. The RV [reducing agent?] yield usually attains 46-50 percent of absolutely dry wood. One ton of absolutely dry wood can produce 200-235 kg of yeast ((1), p 17).

Sulfuric and hydrochloric acids are used for the most part in concentrated acid hydrolysis. Hydrolysis is performed at low temperatures without heat consumption. In this case we observe insignificant breakdown of sugars, their yield from processed raw material increases to 60 percent, while the yeast yield rises to 280 kg/ton. Hydrolysates formed with this procedure are distinguished by a high sugar concentration and better quality.

One of the methods of hydrolysis using concentrated sulfuric acid in our country is known as the Riga method. This hydrolysis method essentially entails influence upon mechanically macerated plant raw material by a small quantity of concentrated sulfuric acid containing 75 percent monohydrate. Hydrolysis temperature is 50-60°C.

Most researchers and hydrolysis specialists interpret hydrolysis basically as transformation, by an acid, of polysaccharides contained within plant tissue into a monosaccharide (1). In this case the organic nitrogenous compounds, resin acids, and other compounds in the group of substances extracted from plants are not taken into account (12). This group of substances makes up only 5-10 percent. But the significance of these substances, both to the plant's vital activities and to processes occurring in hydrolysis, is apparently not directly dependent on their quantity.

Some of these extracted substances participate in microbiological protein synthesis, and for this reason we are not indifferent as to whether they pass into the extract--that is, the hydrolysate, or into the residue (lignin).

Substances known as extractives contain heteropolysaccharides (plant resins), which are much more difficult to hydrolize in view of the presence of bonds differing from those found in homopolysaccharides.

It is also significantly more difficult to hydrolize nitrogen-containing compounds having peptide bonds.

Going on to the problems of hydrolizing plant tissue from the standpoint of transforming, into dissolved state, not only sugars but also other substances important to biosynthesis, we can confidently state that hydrolysis with concentrated acids is more profitable. This advantage is especially noticeable in hydrolysis of peat, which contains, as we know, up to 40 percent humic substances, which go into solution partially only when concentrated acids are used in hydrolysis.

6.3 Chemical Composition of Hydrolysates From Plant Raw Material and Peat

Beginning his analysis of the chemical composition of plant tissue hydrolysates, the analyst would rightfully expect them to contain a very complicated complex of substances due to the chemical composition of the plant cell. I. I. Nikitin (12) points out that all wood substances are in the high molecular weight class of compounds. Schematically classifying the chemical components of wood, he subdivided them into two groups:

1) The most important components of the cell wall, which included cellulose, hemicellulose, and lignin, or 90-95 percent of the total mass of absolutely dry wood;

2) extractives, discussed above, making up 5-10 percent.

Were we to look at a mature plant cell from the botanical point of view (9), we would see three components--a more or less dense membrane clothing the cell on the outside, living contents including cytoplasm and organelles (nucleus, plastids, mitochondria, and so on), and vacuoles filled with cellular fluid.

When plant tissue is hydrolyzed the integrity of the cells is disturbed, and cellulose and hemicellulose monomers as well as fragments of lipids, nucleic acids, and proteins, included in the extractive group, end up in the hydrolysates. Obviously among these fragments of high molecular weight substances we should find those which are physiologically active.

The chemical composition of plant tissue (wood waste) hydrolysate* is characterized by the following data (percent):

Dry matter	5.6-5.8
Total RV	3.06-3.48
Pentoses	1.3-1.57
Colloidal substances	0.21-0.24
Humic substances	0.70-0.85
Uronic acids	0.190-0.330

*Hydrolysate from the Bobruysk Hydrolysis Plant.

Volatile acids	0.28-0.34
Furfural	0.048-0.053
Fe^{2+}	0.016-0.122
Total acidity	0.647-0.840
Total nitrogen	0.0315-0.0365
Mineral nitrogen	0.011-0.028
P_2O_5 after combustion	0.011-0.028
P_2O_5 without combustion	
Monosaccharides:	
Glucose	0.93-1.69
Mannose	0.50-0.65
Xylose	0.72-0.89
Arabinose	trace-0.28
Rhamnose	trace
Galactose	0.01-0.4

Peat has a more complex composition than does wood, and in contrast to it, it contains many humic substances which partly pass into the hydrolysates upon hydrolysis with concentrated sulfuric acid, and partly settle in the nonhydrolizable residue.

The chemical composition of peat hydrolysate is presented below (percent) (35):

Dry matter	13.0
Colloids	7.77
Humic substances	5.40
RV	5.04
RV after precipitation of nonsaccharides	3.80
Acidity	3.25
Ash	0.48
Nitrogen	0.105
P_2O_5	0.02
Organic acids	0.144
Volatile acids	0.076
Furfural	0.0144

As we can see from these data, peat hydrolysate contains polysaccharide fragments, humic substances, bitumens, fulvic acid, and extractives.

6.4 Preparation of Hydrolytic Media for Biochemical Processing

The completeness with which the ingredients of a hydrolysate are utilized depends in many ways on the hydrolysis and inversion conditions, the conditions under which the hydrolysate is neutralized, and the sort of yeast culture. We know how great an influence improvement of hydrolysates, their neutralization in particular, has on the yeast yield.

Various methods for neutralizing hydrolysates have been proposed during the time of existence of domestic hydrolysis-yeast industry. Lime neutralization coupled with directed crystallization of gypsum has assumed a firm foothold in plant practice. This neutralization method was thoroughly analyzed by Korol'kov, Epshteyn, et al. ((21), pp 141-166).

We now have neutralization methods that make use of milk of lime or ammonia water as the neutralizing agent, and a two-step neutralization method using milk of lime in the first step (to neutralize sulfuric acid) and ammonia water in the second step (to neutralize organic acids) ((22), p 87). Fisher (20) suggested adding, to the hydrolysate prior to neutralization, ammonium sulfate in a quantity that would satisfy the yeast's need for nutrient nitrogen by 60-70 percent; this significantly exceeds the quantity of $(NH_4)_2SO_4$ used in directed gypsum crystallization. Glushchenko (4) used a stepped hydrolysate neutralization method at one of the plants, first employing milk of lime until a pH of 3.4-3.6 was reached, and then, after settling of the gypsum and its decantation, ammonia water until a pH of 4.2-4.6 was reached. The authors of these neutralization methods noted that at pH 2.8-3.4, sulfuric acid is neutralized, and the subsequent decline in acidity is associated with neutralization of organic acids.

All of these methods were tested by using them to neutralize undiluted hydrolysates. Not one of them produced positive results: The yields of yeast grown on substrates prepared by the indicated methods turned out to be low.

We know that hydrolysates obtained upon hydrolysis of plant tissue by diluted acids contain a significant quantity of organic acids (22). They include volatile acetic, formic, and propionic acids, and nonvolatile oxopentanoic, oxalacetic, and aldobionic acids. Hydrolysates obtained upon hydrolysis with concentrated acids contain a somewhat smaller quantity of volatile acids owing to decreased sugar breakdown. In particular, the concentration of volatile acids in peat hydrolysate is only 0.076 percent, which is about three times less than in plant tissue hydrolysate.

We know that the state and behavior of various substances in any medium depend to a greater or lesser degree on the properties of the medium, particularly on its acid-base properties. An increase in the medium's acidity or alkalinity often elicits or intensifies ionization of the substances, which in turn leads to an increase in their reactivity.

Acid-base reactions play a large role in many biochemical processes, the specificity of which is often defined by a very narrow interval of medium acidity or alkalinity.

The classical theory of acid-base catalysis ascribes catalytic action exclusively to hydrogen and hydroxyl ions. As an example sugar inversion, acetal hydrolysis, and other reactions have been said to be catalyzed only

by hydrogen ions. But it was later established that reactions accelerated by H^+ and OH^- ions are also catalyzed by undissociated acid and base molecules and other ions, for example the NH_4^+ ion.

Increasing the concentration of substrates being processed is the sole way for increasing yeast yield at existing plants. Today's maximum concentration of RV in industrial hydrolysates is 3-3.5 percent. As we know, an increase in RV concentration is accompanied by a concurrent rise in the concentration of harmful admixtures--furfural, oxymethyfurfural, and humic substances.

Humic substances are a complex of organic substances of as yet unknown structure. It is hypothesized that they are "sugar breakdown products" and that they are harmful to yeast. In fact (if we make an analogy with the humic substances of peat), these are high molecular weight mixed biopolymers containing nitrogen, phosphorus, organic acids, and microelements.

A method for preparing substrates resulting in an acid-base equilibrium in the medium at which all organic acids are utilized and substances contained within the composition of "humin" exhibit their action was developed with a consideration for the existence of this complex of humic substances, as well as of presence of various organic acids in the hydrolysates of all plant tissues and peat. With this purpose a fully definite quantity of ammonia water, necessary for binding of only organic acids, is introduced into the hydrolysate (t=80-90°C). The hydrolysate is additionally neutralized by milk of lime up to pH 4.2-4.4 while blowing air through the hydrolysate; it is kept at these conditions for 1 hour, after which it is separated from gypsum by decantation. Cultivation of yeast in undiluted neutralysates prepared in this manner showed that the yeast biomass yield is 50-60 percent of the prescribed RV.

Because some plants prepare neutralysate for direct use in yeast and alcohol production operations, producers became apprehensive that neutralysate prepared in this fashion would contain too high a quantity of gypsum, which would cause trouble in alcohol production, settling on the walls of the fermentation columns.

Determination of gypsum in neutralysates prepared by various methods showed that its content varies. The gypsum concentration in neutralysate prepared by the method described above is within 0.21-0.22 percent, which is fully permissible for practical purposes. The following forms of neutralization of undiluted hydrolysates were employed in an effort to develop a method for preparing substrates:

1. Lime neutralization at t=80°C to pH 4.2-4.3, with mechanical agitation.

2. Neutralization coupled with directed gypsum crystallization.

3. Ammonia neutralization up to pH 4.2-4.3 at t=80°C, with mechanical agitation.

4. Mixed neutralization--addition of ammonia water as the nitrogen nutrient for yeast in the following quantities--30 percent of the nutritional nitrogen need, 50 percent, and 70 percent--and additional neutralization with milk of lime up to pH 4.2-4.4 at a temperature of 80°C, with air blown through the hydrolysate (Table 6.2). After the gypsum concentration was determined in all neutralysate samples by two methods (5,14), a graph was plotted (Figure 6.1). It was found that depending on the concentration of volatile acids in the hydrolysate, curves *1* and *2*, which represent the quantity of gypsum in the neutralysate, determined by two methods, would intersect at different points, corresponding to the acid-base equilibrium at which all Ca^{2+} ions bind with SO_4^{2-} ions, and organic acids bind with NH_4^+ ions, forming ammonium salts that can be assimilated by the yeast.

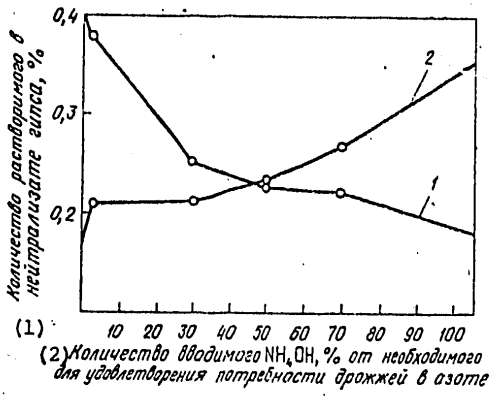

Figure 6.1 Neutralysate Acid-Base Equilibrium Created by Successive Introduction of Ammonia Water and Milk of Lime into the Hydrolysate until pH 4.0-4.2 is Reached: *1*--Quantity of gypsum dissolved in neutralysate, determined on the basis of Ca^{2+}; *2*--quantity of gypsum dissolved in neutralysate determined on the basis of SO_4^{2-}

Key:

1. Gypsum quantity dissolved in neutralysate, percent
2. Quantity of NH_4OH introduced, percent of that satisfying yeast nitrogen demand

Table 6.2 Effect of Hydrolysate Neutralization Method On Yeast Biomass Yield

Neutralization Method	Wort RV, %	Wort pH	Yeast Yield, % RV	Total Protein, %	Unutilized RV, %
Blowing air through hydrolysate for 1.5 hours. Stepped neutralization with milk of lime up to pH 3.0 and with ammonia water up to pH 4.2	3.05	4.2	43.0	48.3	8.8
Blowing air through hydrolysate for 1.5 hours. Neutralization to pH 4.2 coupled with directed gypsum crystallization	3.05	4.2	42.3	51.8	8.0
Initial introduction of ammonium sulfate in a quantity satisfying the yeast's nutrient nitrogen need by 70%, and further neutralization with milk of lime to pH 4.2	3.05	4.2	39.8	46.8	13.4
Introduction of nutrient nitrogen in the form of ammonia water at 70% of demand, and additional neutralization with milk of lime up to pH 4.2 while blowing air through hydrolysate	3.05	4.2	42.0	48.1	3.6
Introduction of nutrient nitrogen in the form of ammonia water at 70% of demand, and additional neutralization with milk of lime to pH 4.2 while blowing air through hydrolysate	3.05	4.2	56.0	50.0	3.6

Note: An osmophilic polyploid strain of *Candida tropicalis* yeast was employed.

As an example the concentration of volatile acids in the hydrolysates is 0.15-0.25 percent when the hydrolysate RV concentration is 3.0 percent. If we assume that 80 mg nitrogen is required to produce 1 gm dry yeast and the yeast yield is 50 percent of the RV concentration, we would need $1.5 \times 50 \times 0.5 = 60$ mg or 70 mg NH_3 to grow 1 mg yeast when only half of the required quantity of nitrogen is supplied. When the concentration of volatile acids in the hydrolysate is 0.25 percent (corrected for acetic acid), their

neutralization would require about 146 mg ammonium hydroxide in the reaction

$$CH_3COOH + NH_4OH \rightleftharpoons CH_3COONH_4 + H_2O$$

or 70 mg NH_3. Thus an equilibrium would be reached in the plant tissue hydrolysates obtained in the production conditions of the Bobruysk plant by adding a quantity of ammonium hydroxide equivalent to 50 percent of the yeast's nitrogen demand.

Analysis of nitrogen-containing compounds in hydrolysates revealed that only preliminary introduction of ammonia water coupled with subsequent additional neutralization to pH 4.2-4.4 with milk of lime would ensure preservation of nitrogen-containing compounds in the hydrolysate (Table 6.3).

Table 6.3 Loss of Ammonia in Different Neutralization Methods

(1) Вид нейтрализации	(2) N, мг в 100 мл		
	(3) Введено в гидролизат	(4) Общий N субстрата	(5) Изменение содержания N
(6) NH_3 до pH 4,2	200,0	186,9	—14
(6) 70% NH_3 + CaO до pH 4,2	82,0	80,0	—2
50% NH_3 + CaO » pH 4,2	58,0	66,0	+8*
30% NH_3 + CaO » pH 4,2	35,0	40,1	+5,1*
(7) Известковая нейтрализация	11,3	0,0	—11,3
С направленной кристаллизацией гипса (8)	5,0	8,3	—8,0
Кислый гидролизат (9)	11,3	—	—11,3

Note: *Hydrolysate nitrogen content increases due to its release through ammonia breakdown.

Key:

1. Form of neutralization
2. N, mg per 100 ml
3. Introduced into hydrolysate
4. Substrate total N
5. Change in N content
6. Up to
7. Lime neutralization
8. Coupled with directed gypsum crystallization
9. Acid hydrolysate

When two-step neutralization is employed, nitrogenous compounds are lost irreversibly first with milk of lime and, after separation of gypsum with ammonia water, together with the separated gypsum. Such nitrogenous

compounds include amino acids, nucleic acids, and high molecular weight humic acids. All of these compounds are biologically active substances.

When ammonia is introduced first, ammonia nitrogen binds with the humic acids, possibly transforming them into amide acids ((2), p 444).

Thus the order in introduction of neutralizing agents has a significant influence on the qualitative state of the obtained neutralysate used to grow yeast. When ammonia is introduced first, the resulting neutralysates are not only richer in nitrogen compounds but they also contain physiologically active compounds which, as we know, are yeast growth stimulants.

6.5 Microbial Protein Biosynthesis in Concentrated Sugar Solutions

Today's industry cultivates nutrient yeast in media having an RV concentration not greater than 1.5-2 percent. In the opinion of many researchers the extent to which the concentration of processed substrates could be increased is limited by aerial oxygen fed into the innoculators.

Thus laboratory research conducted by P. N. Fisher (20) showed that the concentration of sugar in the processed medium and, consequently, its initial concentration in the substrate could be increased significantly (to up to 3-5 percent RV); for this purpose we would have to supply an adequate quantity of dissolved oxygen to the yeast. The biomass yield, expressed as a percentage of the consumed sugar, does not depend on its concentration in the initial medium, if the yeast is supplied with dissolved oxygen during the time of its growth. The concentration of protein, phosphorus, and ash in the yeast also remains constant, not depending on the concentration of sugar in the medium. Tokarev, Korol'kov, and Kozlov (17) point out two circumstances preventing the processing of undiluted hydrolytic media--their low biological quality, and the difficulty of designing the yeast growing apparatus. In their opinion given the air distribution systems employed at existing hydrolysis plants (airlift, vibrational dispersion) in the yeast growing apparatus, the degree to which media undergoing processing are saturated with oxygen does not permit maintenance of a working concentration of yeast undergoing cultivation above 30-35 gm/liter (corrected for pressed yeast).

In the presence of a stepped system for processing undiluted hydrolysate, hexoses are utilized in the head yeast growing apparatus, and pentoses are utilized in the tail apparatus. A yeast unit growth rate corresponding to a 2.5 hour presence of yeast and medium in the apparatus can be achieved in the first cultivation step. The yeast growth rate in pentose sugars (the second cultivation step) is much lower, corresponding to a presence of yeast and liquid in the apparatus of 5 hours. Due to the long time yeast must remain in the apparatus, given the same biomass yield the two-step cultivation method is not suitable. Specialists studying the processing of undiluted hydrolysates suggest: 1) Initially aerating the starting

medium for 4 hours (to remove volatile inhibitors and saturate the medium with oxygen), and the begin processing the prepared medium at a high yeast concentration; 2) blow steam through undiluted hydrolysate, and then prepare substrates from it; 3) artificially keep the liquid in the yeast growing apparatus with a built-in flotation unit while concurrently maintaining the working yeast concentration at the prescribed level.

As we can see from this review, a satisfactory solution to the problem of processing undiluted media has not been found as yet. The powerful air pumping systems installed in new yeast plants fail to produce the desired effect of increasing the yeast biomass yield, they make it more difficult to service such units, and they increase the cost of the end product.

It appeared obvious that we would have to initiate a search for another way to process 4-6 and 8 percent sugar solutions for yeast production.

Back in the 1930's-1940's Engel'gardt suggested the idea of substituting oxygen, which is required for yeast respiration, by some chemical compound. It is still difficult to judge whether or not oxygen could be completely substituted by chemical compounds, but it is possible to regulate oxygen consumption to achieve its more-economical consumption for biosynthetic needs.

We know (9,10) that potassium plays a major role in sugar synthesis. Rubin (16) noted that potassium increases protoplasm's hydrophilic properties, increases its water retention capability, and thus ensures favorable conditions for synthetic processes in the cell. Potassium ions have an influence on osmotic pressure in the cell, activating the nutrition process.

Studying the properties of yeast cells grown in anaerobic conditions in a medium containing potassium ions, Bartley (31) found that a potassium ion concentration less than 3.2 μM inhibits protein synthesis and causes cell growth to slow down. He demonstrated that cells grown in anaerobic conditions in potassium-deficient media can adapt to aerobic conditions only after a significant quantity of potassium is added to the medium. Otherwise even if oxygen availability is unlimited, adaptation of cells to aerobic conditions cannot be observed.

Studying plant respiration, Turkova (18) noted that potassium availability has an effect on respiration intensity. A potassium deficiency usually leads to an increase in respiration intensity, while its addition to the nutrient medium reduces the rate of respiratory gas exchange. The author explains activation of respiration in the presence of a potassium deficiency by change in nitrogen metabolism and tissue intoxication.

Any changes in the nature of metabolism and growth accompanying changes in external conditions (temperature, nutritional conditions, the medium's gas composition) are usually accompanied by significant shifts in the intensity of respiration, and aritificial intensification of respiration in the presence

of deficient nutritional, temperature, and other conditions would lead to change in the nature of metabolism that is not always beneficial to microbial protein synthesis.

Arriving at a choice of conditions for microbial protein synthesis in concentrated media (undiluted hydrolysates), we suggested that the completeness of sugar utilization in such media would depend in many ways on the potassium concentration. To test this hypothesis we prepared synthetic media having sugar (glucose) concentrations from 2 to 8 percent. P_2O_5 and N sources were introduced into these media in accordance with GOST [All-Union State Standard] norms, and varying quantities of potassium were introduced (27 mg per gram absolutely dry yeast was taken as the norm). Potassium was added in the form of the salt K_2SO_4. Two types of yeast were cultivated in the prepared media--Riga *Pichia* (27) and osmophilic *Candida tropicalis* (28). The results of the experiments are summarized in Table 6.4. The data in the table show that as the quantity of potassium added to the nutrient medium increases, the yield of yeast biomass and its total protein concentration increase.

Table 6.4 Effect of Potassium on Development of Osmophilic *Candida tropicalis* Yeast Biomass

Наименование показателей (1)	(2) Значения показателей, %					
	(3) 4% РВ		6% РВ		8% РВ	
	К100%	К120%	К100%	К140%	К100%	К160%
Выход дрожжей (4)	50,0	51,7	45,0	51,7	40,0	51,0
Общий протеин дрожжей (5)	52,6	56,6	46,6	50,4	47,2	54,3
Белок истинный (6)	50,5	55,8	40,2	45,2	41,3	52,63
Общее содержание нуклеиновых кислот в дрожжах (7)	—	—	9,6	8,5	9,3	9,0
Утилизировано РВ (8)	90,0	99,0	88,0	98,8	86,0	98,6

Key:

1. Index
2. Index values, %
3. RV
4. Yeast yield
5. Total yeast protein
6. True protein
7. Total yeast nucleic acid content
8. RV utilized

Thus the permeability of sugars and their assimilation depend on the amount of excess potassium (over the norm) in the medium.

Presence of several systems for penetration of sugars into the cell, differing in relation to associations with energy reactions, has been hypothesized for microorganisms, yeast in particular. A significant role is ascribed in this case to polyphosphates in relation to yeasts (34).

Van Stevenick (35) experimentally showed that the quantity of polysaccharides outside the cell membrane drops significantly when glucose penetrates into the yeast cell. This permitted him to suggest the hypothesis that passage of glucose into the yeast cell is associated with enzymatic phosphorylation by polyphosphates serving as the phosphate donor.

F. Jungnickel (32) studied the influence of various factors in yeast respiration on formation of polyphosphates and assimilation of potassium by phosphate-poor *Candida utilis* cells. He established that when sugar is added, the potassium concentration must be increased to permit both intensified formation of polyphosphates and equalization of the charge by intermediate products of the Krebs cycle. It was noted that after supplementation of the nutrient medium with sugar the demand for potassium and for acidification of the medium increased sharply, while the concentration of orthophosphate decreased.

Kurtf A. Santarius (33) made mention of a decline in the total phosphorus concentration in yeasts grown in solutions having a high sugar concentration.

Determination of polyphosphates in yeast grown in concentrated synthetic media showed that their total content grows in proportion to the amount of potassium added. The growth was greatest in the physiologically most active acid-insoluble fraction (Table 6.5). Thus Stevenick's conclusion that the permeability sugars exhibit in relation to the yeast cell is the product of presence of polyphosphates in the cell was confirmed. It is obvious that potassium promotes formation of polyphosphates in the living cell, thus intensifying permeability of sugars into the cell. The highest glucose utilization was observed when a sufficient quantity of potassium was introduced. The potassium demand differs for different species of yeasts. Experiments have shown that Riga *Pichia* yeast culture is the most sensitive to a potassium deficiency.

Similar data indicating that yeast has a high potassium demand were obtained with substrates prepared from undiluted plant material hydrolysates.

To obtain hydrolysates with an RV concentration of 4-8 percent, industrial hydrolysates with an RV concentration of 3.1 percent were steamed under a vacuum. Nutrient media with RV concentrations of 2, 4, 6, and 8 percent were prepared from the steamed hydrolysate, and nutrient nitrogen and phosphorus sources were introduced in correspondence with the RV concentrations. Potassium was introduced in the form of the salt K_2SO_4 into the control media at a dosage of 27 mg per gram absolutely dry yeast, and into experimental media at dosages 20, 40, and 60 percent greater.

Table 6.5 Concentration of Protein and Polyphosphates in Osmophilic Yeast Following Addition of Different Quantities of Potassium to the Nutrient Medium

(1) Раса дрожжей	(2) Конц. калия, % от нормы	(3) Выход дрожжей, % от РВ	(4) Утилизация глюкозы, % от исх.	(5) Содержание общего протеина, %	(6) Общий P_2O_5, %	(7) Кислоторастворимые полифосфаты	(8) Кислотонерастворимые полифосфаты
						мг P_2O_5 на 1 г сухих дрожжей (9)	
(10) Candida осмофильная	0	37,9	80,0	47,8	4,76	10,89	13,58
(11) То же	50 (13,5 мг/г) (12)	43,6	86,0	48,87	5,22	7,35	14,65
»	100 (27,0 мг/г)	60,0	98,0	49,1	4,15	6,99	16,18
»	150 (40,0 мг/г)	61,8	100,0	49,5	5,04	6,55	18,19
Pichia	0	19,7	50,0	45,20	3,37	7,79	11,16
Рижская (13)	50	24,56	80,0	46,50	3,23	5,46	12,66
То же (11)	(13,5 мг/г)						
»	100 (27,0 мг/г)	42,5	96,0	47,56	3,20	5,41	13,76
»	150 (40,0 мг/г)	43,8	100,0	49,30	3,95	5,55	14,58

Key:

1. Yeast race
2. Potassium concentration, % of norm
3. Yeast yield, % of RV
4. Glucose utilization, % of initial
5. Total protein content, %
6. Total P_2O_5, %
7. Acid-soluble polyphosphates
8. Acid-insoluble polyphosphates
9. mg P_2O_5 per gm dry yeast
10. Osmophilic
11. As above
12. mg/gm
13. Riga

Yeasts were grown in the prepared media and then analyzed for protein and nucleic acids. The mash residue following yeast cultivation was analyzed for residual RV and monosaccharides. The experimental results are summarized in Table 6.4.

It follows from the data in Table 6.4 that yeast substrates with a higher sugar concentration, up to 8 percent, could be achieved and utilized, on the mandatory condition that excess nutrient potassium is present. In this case the assimilability of sugars remains at approximately the same level, while when extra potassium is not added sugar utilization drops as the RV concentration increases. Total yeast protein also increases owing to true protein, but the total nucleic acid content decreases insignificantly as the quantity of potassium introduced into the nutrient medium rises.

The yeast biomass yield drops insignificantly when the RV concentration of the substrate is increased from 2 to 4 percent, but at a concentration of 8 percent the biomass yield attains only 40 percent. Thus the sensitivity of yeast to sugars is especially noticeable beginning with dissolved sugar concentrations of 6-8 percent. In these cases the permeability and the assimilation of sugars are activated by potassium.

6.6 Some Problems in the Theory and Technology of Microbial Protein Synthesis Using Peat Substrate

One of the raw materials used to produce nutrient yeast is weakly decomposed, so-called bedding peat, the reserves of which total millions of tons in the Soviet Union.

Bedding peat is a hindrance to extraction of fuel peat, and for this reason organization of integrated peat extraction has great national economic significance.

It was about 30 years ago that we began concerning ourselves with the problem of utilizing weakly decomposed peat to produce nutrient yeast in the Soviet Union. Thus in 1936-1938 Sharkov and Skrigan (23) studied hydrolysis of peat with diluted acids, and they grew nutrient yeast in the obtained hydrolysates. Production of yeast from peat could not be organized at that time in view of the low yeast biomass yield produced from peat substrates, as well as due to difficulties in separating the peat pulp into its liquid and solid phases.

Further research on various methods for and conditions of mineral acid hydrolysis showed that one of the prospective methods for hydrolyzing peat was to use small quantities of concentrated sulfuric acid combined with mechanical agitation. The hydrolysis reaction proceeds at a temperature of about 100°C, owing to which the losses of monosaccharides decrease significantly and the obtained hydrolysates have RV concentrations of 5-7 percent.

In contrast to wood, peat contains much more humus. This sharply alters the pattern of all processes involved in peat processing--hydrolysis, inversion, filtration, substrate preparation, and yeast cultivation (29). The theory and technology of hydrolyzing peat with concentrated sulfuric acid were developed on the basis of the results of theoretical research conducted by Odintsov, Kal'nina, and others (6,13). The complex composition of peat hydrolysates, particularly the high concentration of humic substances, requires a more cautious approach to preparation of substrates from them for biological processing. The preparation conditions must satisfy two requirements: Impurities toxic to yeast must be removed from the hydrolysate, and dissolution and maintenance of an optimum quantity of physiologically active humins, especially their high molecular weight fraction--humic acid, must be ensured. Humic acids revealed in peat hydrolysates in humate form attest to the difficulty of hydrolyzing them, and to presence of peptide

bonds within them, since amino acids begin to appear in the hydrolysates when the humates are subjected to hydrolysis in harsher conditions (6N H_2SO_4, t=100°C, hydrolysis time 18 hours).

It was established through laboratory experiments that in contrast to wood hydrolysates, when peat hydrolysates are subjected to considerable neutralization (up to pH 4.5-5), more humates enter into solution and yeast growth is inhibited.

The best method was found to be combined neutralization of hot hydrolysate first with ammonia water and them milk of lime up to pH 4.2-4.4 while blowing air through the hydrolysate. But because hydrolysis, inversion, and neutralization are performed in apparatus not made from acid resistant steel, a heightened concentration of iron is revealed in the hydrolysate in the form of iron ions. When nutrient phosphorus sources were added to the neutralysate, iron ions formed complexes with unhydrolized humins and phosphorus; these complexes could not be assimilated by the yeast, as a result of which its quality and yield dropped. In addition, separation of inverted peat pulp into its liquid and solid phases proceeded with greater difficulty in view of the colloidal properties of the pulp structure, and it was accompanied by losses of sugars.

A method for neutralizing pulp without preliminary separation of the unhydrolizable residue was proposed (30). The essence of the method is that following inversion, a fraction of the nutrient nitrogen required by the yeast is added in the form of ammonia water, and then the hydrolysate is neutralized with milk of lime to a pH of 4-4.2 at a temperature of 80-85°C. After the neutralized pulp is kept at this temperature for 1 hour and air is blown through, the neutralysate is separated by filtration. In an acid environment, iron is present in hydrolysate in the form a salt, while at pH 4.2-4.4 it binds into a complex with humins, which pass into the unhydrolizable residue.

Substrates prepared from hydrolysates contain about two times more iron that do substrates prepared by the pulp neutralization method (0.21 and 0.12 percent respectively). Moreover the rate of filtration of neutralized pulp is twice higher than that of acid pulp owing to change in its structure; the loss of RV with precipitant decreases by 12-18 percent; the residue is not hydrophilic; outlays of electric power, steam, and water decrease because the process occurs in one step; when the pulp is neutralized the filtrate becomes practically completely free of heavy metals; the substrate is translucent and precipitate does not form in it, and thus the P_2O_5 consumption does not exceed normal; the rate of yeast reproduction is normal; the yeast quality is high (the protein concentration is 50-56 percent). Blowing hot air through the pulp while adding ammonia water and lime until a pH of 4.2-4.5 is reached leads to additional hydrolysis of humins and a significant increase in the quantity of RV (a 12-18 percent increase).

Peat hydrolysates contain a broad assortment of substances that serve as nutrients for yeast. The set of various organic acids (amino acids, uronic, humic, and so on) is especially rich. This necessitated discovery of yeasts that could utilize these substances.

The Latvian SSR Academy of Sciences Institute of Wood Chemistry selected out a polyploid yeast strain. It changed its form depending on the nutrient composition and on other external conditions, but utilization of all components of the medium was complete and yeast quality was high (the protein content attained 58 percent).

Because peat hydrolysates contain additional nutrient carbon sources (various acids and humic substances) not within the RV composition, the quantity of added potassium and phosphorus sources exceeded the norm adopted in yeast production by 10-20 percent. The yeast biomass yield from a quantity of RV in substrates prepared from peat hydrolysate and from inverted peat pulp was 50-55 and 55-65 percent respectively.

The Institute of Wood Chemistry proposed, theoretically grounded, and practically tested methods for preparing substrates from plant tissue (wood waste in particular) andpeat hydrolysates characterized by the fullest utilization of substrate components in microbial biosynthesis.

The method of preparing substrates from undiluted industrial wood hydrolysates was tested at the Bobruysk Hydrolysis-Yeast Plant, it produced positive results, and it will be introduced here on an industrial scale.

The method of preparing substrates from peat was also tested in experimental industrial conditions and placed at the basis of the equipment and production conditions of a new plant in the Latvian SSR producing yeast from peat.

The new yeast strains proposed, Riga *Pichia* and osmophilic *Candida*, passed the plant tests successfully, but they have not been introduced as yet because not a single hydrolysis-yeast plant is now processing undiluted hydrolysates.

Cultivation of yeast in concentrated sugar media to which potassium is added in an amount exceeding the existing norm is now a reality only at the laboratory research level.

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ENVIRONMENTAL AND ECOLOGICAL PROBLEMS

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WORK WITHIN CEMA IN THE FIELD OF MEASUREMENTS OF IONIZING RADIATION

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 1, 1979 pp 25-27

/Article by M. F. Yudin and F. M. Karavayev (USSR), K. Zhdanski (Hungarian People's Republic), Z. Referovskiy and M. Derezhinski (Polish People's Republic), G. Rothe (GDR) and L. Kokta (CSSR)/

/Text/ During the period following the publication /1/ work on ensuring the unity and correctness of measurements of ionizing radiation in CEMA countries continued to develop successfully. In 1974-1976 the CEMA Permanent Commission on Standardization approved the following sets of means of measurements as CEMA standards:

the standard of a unit of activity of radionuclides within the national standards of the Hungarian People's Republic, GDR, USSR and CSSR, for the range below 1 MBq, and within the UEA-4 and UEA-5 standard apparatus of the USSR state primary standard, for the range from 1 MBq and higher;

the standard of a unit of exposure dose of photon radiation within the national standards of the Hungarian People's Republic, GDR, Polish People's Republic and USSR;

the standard of a unit of absorbed dose of beta-radiation within the national standards of the GDR and USSR;

the standard of a unit of absorbed dose of neutron radiation within the USSR state primary standard;

the standard of a unit of neutron radiation flux within the USSR state primary standard;

the standard of a unit of density of neutron radiation flux within the USSR state primary standard;

the standard of a unit of power of absorbed dose of photon radiation (with 1.25 MeV energy) within the national standards of the GDR and USSR.

Instead of the check schemes previously in effect new check schemes for the means of measurements of the activity of radionuclides, exposure dose of photon radiation and neutron radiation flux and flux density were approved in 1978. The rules of keeping and applying CEMA standards envisage a periodic comparison of the national standards forming part of CEMA standards. Other CEMA members, which have the appropriate means of measurements, can join these comparisons.

Comparisons of the standards of a unit of activity of radionuclides were made in 1974 with the participation of specialists from the following laboratories, keepers of the national standards forming part of CEMA standards: of the State Administration of Metrology (OMKh) of the Hungarian People's Republic (K. Zhdanski and A. Sereni), of the Administration for Standardization, Metrology and Testing of Goods (ASMV) of the GDR (G. Rothe and H. Greipner), of the All-Union Scientific Research Institute of Metrology imeni D. I. Mendeleyev (VNIIM) of the USSR (F. M. Karavayev, A. Ye. Kochin and A. F. Drichko) and of the Institute for the Production, Application and Investigation of Radioisotopes (UVVVR) of the CSSR (L. Kokta and Ya. Sderadichka). Representatives of the laboratory of the Polish Committee on Standardization and Measures (PKNiM) (M. Derezhinski and N. Paź) participated in the comparison of the standards of a unit of activity of γ-emitting radionuclides.

The working standards of VNIIM--sources of γ-radiation ^{137}Cs No 396 and No 818--were used for a comparison of the standards of a unit of activity of γ-emitting radionuclides. The activity of ^{137}Cs in these sources was measured on the UEA-4 standard apparatus of the USSR state primary standard /2, 3/ by the ionizing method. In ASMV, OMKh, UVVVR and PKNiM the activity of ^{137}Cs in the sources of VNIIM was measured by the relative method by comparing them with similar internal sources or with ampoules with ^{137}Cs solution by means of ionization chambers (in UVVVR). The comparison results are presented in table 1, where random and systematic errors are summed up (for fiducial probability 0.99) according to the method of the International Commission on Radiological Units and Measurements /4/. When the activity of ^{137}Cs was determined, the presence of ^{134}Cs admixture in sources, as well as self-absorption and absorption in ampoule walls, were taken into account.

From the data presented it follows that the deviations of the values of activity of ^{137}Cs in sources measured in OMKh, ASMV, VNIIM and UVVVR from the mean values amounting to $4{,}196 \cdot 10^9$ and $3.434 \cdot 10^8$ Bq do not exceed 1%, that is, much less than the evaluated errors of measured values. This means that the systematic error of measurements by all the participants in the comparison is greatly overstated. Thus, the comparison made permits a significant reduction in the error of measurements of the activity of γ-emitting radionuclides.

The comparison of the standards of a unit of activity of β-emitting radionuclides was made by means of ^{137}Cs and $^{90}Sr+^{90}Y$ solutions. The measurements were made by the 4πβ-counting method on the standard apparatus of member countries. For the determination of corrections for self-absorption

the indicator extrapolation method was used in OMKh, ASMV and UVVVR. The results of comparisons are presented in table 2, where the total error is determined by the method of the International Commission on Radiological Units and Measurements [4] for fiducial probability 0.99.

Table 1.

(1) Лаборатория	(2) Источник № 396		(2) Источник № 818	
	Активность ^{137}Cs, 10^9 Бк (3)	Относительная погрешность, % (4)	Активность ^{137}Cs, 10^9 Бк (3)	Относительная погрешность, % (4)
ОМХ (5)	4,234	3,2	3,467	2,5
АСМВ (6)	4,181	2,6	3,422	2,7
ВНИИИМ (7)	4,155	6,3	3,404	6,3
УФВВР (8)	4,211	4,3	3,437	4,3
ПКНиМ (9)	4,059	7,0	3,286	7,0

Key:
1. Laboratory
2. Source
3. ^{137}Cs activity, 10^9 Bq
4. Relative error
5. OMKh
6. ASMV
7. VNIIM
8. UVVVR
9. PKNiM

Table 2

(1) Лаборатория	Раствор ^{137}Cs (2)		Раствор ^{90}Sr-^{90}Y (2)	
	Удельная активность ^{137}Cs, кБк/г (3)	Относительная погрешность, % (4)	Удельная активность ^{90}Sr+^{90}Y, кБк/г (3)	Относительная погрешность, % (4)
ОМХ (5)	185,5	1,40	119,2	0,95
АСМВ (6)	186,0	1,57	120,2	0,36
ВНИИИМ (7)	183,8	1,30	120,5	0,55
УФВВР (8)	185,3	1,40	120,4	0,46
	185,8	1,40		
Среднее (9)	185,3		120,1	

Key:
1. Laboratory
2. Solution
3. Specific activity of ^{137}Cs, kBq/g
4. Relative error
5. OMKh
6. ASMV
7. VNIIM
8. UVVVR
9. Average

The results of comparisons showed that the reproduction of a unit of activity of β-emitting radionuclides by the national standards of the Hungarian People's Republic, GDR, SSSR and CSSR (by the CEMA standard) is made correctly without significant unconsidered systematic errors. The deviations of the results obtained on individual standards from the mean values do not exceed the limits of evaluated errors.

The work performed according to the plan of the CEMA Permanent Commission on Standardization in 1971-1973 contributes to ensuring the unity of measurements and to increasing their accuracy. This work proposes the most efficient methods of determining partial correction coefficients taking into account self-absorption and absorption in ampoule walls (for γ-radiation sources), change in the efficiency of a detector during a change in photon energy, attenuation and absorption of photons in the walls of ionization chambers, as well as determinations of coefficients taken into consideration during the measurement of activity by the $4\pi\beta\gamma$-coincidence method. As a result of an analysis of the data published in the literature the most accurate and reliable values of universal constants (photon energy, maximum and average energy of β-particles, number of photons and β-particles per act of decay, half-decay period and so forth) were selected and recommended for radionuclides most often used in metrological practice.

The automated measuring apparatus developed in OMKh and UVVVR are of great importance. They ensure the identification and measurement of the activity of admixture radionuclides in radioactive sources of radiation and in radioactive samples. A many-sided comparison of the standards of a unit of activity of α-emitting radionuclides by means of ^{241}Am solutions is planned for 1979.

Comparisons of the standards of a unit of exposure dose of X-radiation with 10 to 250 keV generated voltage belonging to CEMA members were made in 1974-1975. The comparisons were made separately over the ranges 10 to 60 keV and 60 to 250 keV with the participation of OMKh of the Hungarian People's Republic (K. Zhdanski and I. Khizo); ASMV of the GDR (G. Rothe and K. Helmshtedner); PKNiM of the Polish People's Republic (Z. Referovski, M. Derezhinski and N. Paz); VNIIM (V. I. Fominykh, I. A. Uryayev, G. P. Ostromukhova and R. F. Kononova); only over the range 10 to 60 keV, ChSMU /expansion unknown/ and the Center of Radiation Hygiene (TsGI) of the CSSR (A. Drabek and O. Kodl).

Comparisons of the primary standards of a unit of exposure dose of X-radiation over the range 10 to 60 keV were made by means of a free-air standard comparison chamber belonging to VNIIM and forming part of the USSR state standard of a unit of exposure dose. This chamber and the electrical measuring device of VNIIM with a control radioactive source of $^{90}Sr+^{90}Y$ were transported to each of the participating countries.

Free-air ionization chambers of the plane-parallel type were used in all national standards. The comparison of standards boiled down to the determination of the constant of the comparison chamber of VNIIM by means of the national standards of CEMA members. The substitution method was used for this. Chambers were placed in the beam of X-radiation so that the planes of the limiting diaphragms to which the measured values of exposure doses pertained might be at the same distance from the anode of the X-ray tube.

Table 3 presents the relationships of the results of measurement of the constant of the comparison chamber to the mean arithmetical value of the constant for the CEMA standard.

Table 3

Режим излучения, кВ/мм Al (1)	(2)	(3)	(4)	(5)	(6) СССР,	
					ЧСМУ (7)	ЦИМ (8)
10/0,036	—	0,994	—	1,006	0,957	1,007
30/0,18	1,001	0,997	1,003	1,000	0,984	0,989
		0,995				
50/1,0	1,000	0,998	1,002	1,003	1,006	1,009
60/2,3	0,999	0,993	1,001	1,004	0,969	1,005

Key:
1. Radiation conditions, kV/mm Al
2. Hungarian People's Republic, OMKh
3. GDR, ASMV
4. Polish People's Republic, PKNiM
5. USSR, VNIIM
6. CSSR
7. ChSMU
8. TsGI

From the data of table 3 it follows that the amount of the unit of exposure dose of CEMA members differs from the amount of the unit reproduced by the CEMA standard by no more than 0.7%. On the basis of an analysis of results it was established that the CEMA standard in the indicated energy region is at the present scientific and technical level. During subsequent comparisons, in order to increase the accuracy, it is recommended that a free-air chamber be used, determining by absolute methods the value of the rate of exposure dose in every country by means of the national standard and comparison chamber, not the constant of the chamber, as envisaged in MS15-72 recommendations.

During comparisons over the range 60 to 250 keV free-air chambers of the plane parallel type (OMKh, ASMV and PKNiM) and a cylindrical chamber (VNIIM) were used in all standard apparatus. The cavity chambers of OMKh, ASMV and PKNiM were used as comparison standards. Chamber cavities were connected with the atmosphere. The method of comparisons was similar to that for the 10 to 60 keV energy range.

Table 4 presents the relationships of the results of measurements of the constants of comparison chambers to the mean arithmetical value of the constant for the CEMA standard.

Table 4

Камера (1)	Режим излучения, кВ/мм Cu (2)	НРБ: ОМХ (3)	(4)	(5)	(6)
ОМХ (7)	100/0,15	0,996	1,005	0,999	—
	135/0,50	0,999	0,996	0,995	1,009
	180/1,0	0,995	1,000	1,003	1,002
	220/2,0	—	0,991	0,993	1,010
	250/2,5	1,004	0,995	—	—
АСМВ (8)	100/0,15	0,997	1,007	0,996	—
	135/0,50	1,004	0,997	0,991	1,008
	180/1,0	1,004	1,002	0,993	1,002
	220/2,0	—	1,003	0,998	1,001
	250/2,5	1,001	0,999	—	—
ПКНиМ (9)	100/0,15	0,989	1,006	1,004	—
	135/0,50	0,992	1,005	0,998	—
	180/1,0	1,000	0,995	1,005	—

Key:

1. Chamber
2. Radiation conditions, kV/mm Cu
3. Hungarian People's Republic, OMKh
4. GDR, ASMV
5. Polish People's Republic, PKNiM
6. USSR, VNIIM
7. OMKh
8. ASMV
9. PKNiM

From an analysis of the results of comparisons it follows that the amount of the unit of exposure dose reproduced by the national standards of CEMA members differs from the amount of the unit reproduced by the CEMA standard by no more than 1%, which lies within the error of measurements with national standards. Thus, the CEMA standard over the energy range 60 to 250 keV is also at the present scientific and technical level.

The research conducted enabled the CEMA countries that took part in the comparisons to obtain useful information on the methods and means used in every country, to unify the determination of some correction coefficients introduced into the results of measurements and to increase the reliability of reproduction of a unit of exposure dose of X-radiation over the 10 to 250 keV energy range.

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PUBLICATIONS

DUST STORMS AND AMELIORATIVE MEASURES

Moscow PYL'NYYE BURY I AGROLESOMELIORATIVNYYE MEROPRIYATIYA ("Dust Storms and Agricultural and Forestry Ameliorative Measures") in Russian 1978, signed to press 28 Feb 78, pp 2-6, 159

[Annotation, introduction and table of contents from book by M.I. Dolgilevich, Izdatel'stvo "Kolos", 2340 copies, 159 pages]

[Text] This book presents the theoretical investigations of the author and other scientists on dust storms and wind erosion. The following questions are examined: the nature of dust storms, including critical wind velocities, soil erodibility, soil properties influencing the development of erosion; the influence of wind on soil and plants; classification of wind erosion; dust storms, their periodicity, duration and distribution; soil loss from erosion and its permissible level. A classification of wind-eroded soils is presented. Research on protection of soil against erosion and on the effectiveness of forest-belts in dust storm control in the southern regions of the country is described.

Introduction

Dust storms, as an extreme manifestation of wind erosion of soils, arise periodically in the steppe zone of the European part of the USSR. During dust storms, crops are damaged, and the upper, most fertile layer of soil is carried off. Perennial plantings, dwellings and farm buildings, railroad track and paved roads are covered with fine dirt.

In order to work out a complex of soil preservation measures which could be applied in specific soil and climactic conditions, along with knowledge of the general laws of wind erosion development, it is necessary to know the regional features of these processes.

The first information on dust storms in the south of Russia was obtained in 1774 as a result of P. S. Pallas' travels (I. E. Buchinskiy, 1970). Wind erosion here begins to encompass large territories after agricultural development of black-earth and then brown soils (the abolition of serfdom and colonization of lands served as a significant impetus to the development of new lands in the south of Russia).

After intense dust storms in the south of our country in spring 1928, research, chiefly of a geographic character, was conducted (D. O. Svyatskiy, 1928; A. V. Voznesenskiy, 1930; S. O. Vorob'ev, 1930, 1932). A. V. Voznesenskiy was the first to make a map of dust storm distribution in the territory of the Ukraine; it shows regions of different depths of soil blow-off and dust deposition. Although these data were obtained by questioning local specialists and population, they give an idea of the scale of dust storms.

Materials on the distribution of wind erosion in the form of dust storms, its frequency and certain erosion control measures in the Ukraine were presented in the work of S. O. Vorob'ev (1930). He noted that the most destructive tornados in the Ukraine were in 1837, 1848, 1877, 1892, and 1928; the dust storms covering large territories and causing enormous soil losses. For example, in 1928 the area of territory encompassed by dust storms was 400,000 km^2.

After G. N. Vysotskiy, S. O. Vorob'ev felt it necessary to advance the special problem of dust storm control. Among measures directed at protecting soil from blow-off, he noted the creation of forest belts in fields, spring ploughing of fallow lands and autumn sowing of perennial grasses.

After the Great Patriotic War, research into the effectiveness of agrotechnical and forest amelioration measures for dust storm control was begun.

Among the early postwar research, the work of S. S. Sobolev (1945) devoted to geographical patterns of wind erosion is noteworthy. S. S. Sobolev demonstrated the northern boundary of dust storm distribution in the Ukraine and distinguished territories with different intensities of wind erosion.

D. P. Ryzhikov (1948, 1955, 1957) studied certain yearly factors of dust storm arisal on the Ukrainian steppe. Analyzing data about dust storm attacks during the fall-winter period, he showed that, as a rule, after a dry autumn dust storms arise in the spring of the following year. Studying forest amelioration methods for soil and crop preservation from dust storms, D. P. Ryzhikov noted the high effectivenss of windbreaking forest belts and certain agrotechnical methods.

G. M. Karasev (1956, 1957) conducted field experiments on soil cultivation and furrow planting of grain crops with a view toward increasing the harvest and preserving soil from wind erosion.

The works of G. I. Matyakin (1937, 1952), Ya. D. Panfilov (1937), Yu. P. Byallovich (1940), M. I. Yudin (1950), A. R. Konstantinov (1950, 1951), D. L. Armand (1961), Ya. A. Smal'ko (1963), A. R. Konstantinov and L. R. Struzer (1965) and others have made a substantial constribution to the theory of field-protective forest cultivation. These works served as the basis for creating effective systems of field-protective forest belts in regions of wind erosion of soil in the European part of the country.

Later works confirmed the high soil protective effectiveness of forest belts during dust storms (Yu. K. Teleshek, 1960; N. M. Miloserdov, 1961, 1970, 1971; P. S. Zakharov, 1965; M. I. Dolgilevich, et al., 1969, 1972; M. M. Lazerev, V. D. Savichev, 1969, et al.).

In capitalist Russia ploughing of huge tracts of land and poor harvests led to the frequent arisal of dust storms. At the end of the last century droughts and dust storms in the south of the country attracted the attention of a number of scientists. Here began a period of description of dust storms and investigation of their nature.

As a result of research in the field of dynamic geology conducted by N. A. Sokolov (1884) on Russian sands, the nature and types of movement of sand grains were studied and the initial wind velocities necessary for moving different-sized grains were studied.

Subsequently changes in soil properties under the influence of wind, the character of the manifestation of wind erosion on agricultural lands, on different fields and according to the season of year were studied (A. A. Bychikhin, 1892; N. Sarandinaki, 1894). During the same period, the first attempts to classify dust storms on a meterological basis were undertaken (S. G. Popruzhenko, 1893; G. G. Shenberg, 1915).

At the end of the 19th century, important investigations devoted to studying the nature of dust storms and developing measures of control were organized by V. V. Dokuchaev and conducted under his direction. The most significant of these are the studies of G. N. Vysotskiy (1894). He perfected detailed scientific analysis of the nature of (black) dust storms on the Ukrainian steppe. He found that dust storms are most dangerous in early spring when winter crops have not yet taken hold, when fields are not yet protected by vegetative cover. G. N. Vysotskiy demonstrated the kinematics of an air current in dependence on the relief and character of obstacles in its path. and described the formation dynamics of wind-borne deposits with different obstacles.

These studies also have great significance at the present time. Subsequently the building of experimental constructions in forest-belts has made it possible to reach a number of important conclusions about the mechanism of the influence of forest belts on wind and on the processes of wind erosion related to it.

An expert on agricultural methods in the south of Russia, P. F. Barkov (1913) noted that compacted fields suffered more from wind than uncompacted fields. In this connection, peasants tried to make the soil friable with harrows; this increased the roughness of the soil surface and decreased the injurious influence of the wind on the soil. P. F. Barakov linked the distribution of wind erosion to agricultural practices. In his opinion, fields of sugar beets especially suffer from the wind because the northern boundaries of the developing wind activity and sugar beet cultivation coincide.

Laying down a broad program of investigating the country's natural forces as a basis for land evaluation in 1897, V.V. Dokuchayev felt it indispensible to conduct research into dust storms. Extensive investigation became possible only after the establishment of Soviet power.

After enactment of the decree of the CC CPSU and the USSR Council of Ministers of 20 March 1967 "On Emergency Measures for Protecting Soil Against Wind and Water Erosion," research on wind erosion and development of a complex of soil protection measures intensified.

Along with research on field-protective forest cultivation in the Ukraine, the Northern Caucasus and the lower Volga region, work on study of the soil-protective effectiveness of agrotechnical methods with use of a system of special soil cultivation and sowing machines and equipment developed by the All-Union Scientific Research Institute of Grain Farming, the All-Union Scientific Research Institute of Agricultural Mechanization, the All-Union Scientific Research Institute of Agricultural Machinery and the Kazakh Institute of Rural Mechanization and Electrification and a number of agricultural engineering works was expanded. As a result of investigations, the effectiveness of soil protective cultivation on major crops was demonstrated.

In addition to this, development of the scientific basis of a complex of measures directed toward soil protection against wind erosion requires deep knowledge of the nature of wind erosion, the mechanisms of the influence of wind on soil, especially in carrying out soil protective agrotechnical and forest amelioration measures. Research into the various factors of wind erosion, analysis of diagnostics and classification of soils exposed to wind erosion is no less urgent.

Solution of these questions, to which this book is devoted, is especially important for the southern regions of the European part of the USSR where intensive management of agricultural production requires wide application of a complex of measures for protecting soil from wind erosion.

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PUBLICATIONS

INFORMATION PROCESSES IN NEURAL STRUCTURES

Moscow INFORMATSIONNYYE PROTSESSY V NEYRONNYKH STRUKTURAKH in Russian
1978 signed to press 26 April 1978 pp 2, 3-6, 165-166

[Annotation, foreword, introduction and table of contents from book by V.L. Dunin-Barkovskiy, Izdatel'stvo "Nauka", 1,300 copies, 167 pages]

[Text] The book gives an account of the results of theoretical investigations of the mechanisms of neural activity. The book is closely related in content to the works of Brindley and Marr on analysis of the functions of central nervous structures, particularly the cerebellum.

The first four chapters set forth the fundamental concepts of neurophysiology and neural network theory which are the basis of the current theories to which the second half of the book is devoted.

Here the concepts and methods of information theory are used to interpret functions and evaluate the effectivenss of concrete neural structures. Experimental data are interpreted and new experiments are proposed on the basis of theoretical analysis.

The applicability of selected principles of neural organization to solving problems in the creation of artificial intelligence is explored. The properties of the neuron as a functional element of the computing structures of the organism are enumerated and a variant physical model of the neuron which provides the same functional capabilities is proposed.

The book is intended for specialists in theoretical and experimental neurophysiology.

Fifty one figures, 2 tables, bibliography of 217 titles

Editor-in-chief: Doctor of Biological Sciences, L. M. Chaylakhyan

Foreword

In recent years the concepts and methods of information theory have been penetrating into many branches of science. In particular, the present book shows how the concrete principles of this theory are beginning to be successfully applied to neurophysiology. Until recently, analysis of information transmission along the neural conductors was basically limited

to studying the connection between nerve centers and the mechanisms of stimulus transmissions.

The monograph commended to the reader's attention was written through the program of theoretical biological research conducted at the Institute for Information Transmission Problems of the USSR Academy of Sciences. The goal of these works is in-depth analysis of biological processes with a view toward understanding and applying principles discovered in nature to the creation of complex artificial information systems.

In the monograph information on cell biophysics is systematized which is indispensible for current analysis of works on cell systems. Description and classification of known types of neuron models are given, starting with the classic model of (Mak-Kallok) and Pitt. A significant number of widely used models have been created by the author and his coworkers at the Institute of Information Transmission Problems of the USSR Academy of Sciences. Critical analysis of the basic results and the significance for neurophysiology of the formal neuron and finite automat theory is presented. Analysis of the properties of homogeneous neural ensembles concludes the part of the book not directly related to application and development of information theory methods. Next, the basic methods and results of applying information theory to analysis of neural networks are described. Then the general methods and concepts developed in the beginning of the book are applied to analysis and interpretation of diagrams and principles of the work of the cerebelleum--the brain structure which has been studied in greatest detail. The achievements of theoretical analysis of the nervous system are presented in the form of the so-called principles of neural organization. The concluding chapter of the book is devoted to analyzing the potential applications of neural networks in technology.

Systematization of neural models, development of theoretical information models of neuron memory, analysis of the neural organization of the cerebellum and development of ideas for creating artificial analogues of neural diagrams must be regarded as the most substantial of the author's results published in the book. It is well that abstract constructions are complemented in the book by concrete analysis of concrete structures. In this way, a number of new experiments have been formulated and the results of their probable outcome have been analyzed.

It should be noted that the author of the book is well acquainted with neurophysiological experimentation and technology, as well as theory. It is as a result of this knowledge that so many different themes are combined in the book in reasonable proportion. The works which make up the contents of the book were reported by the author and discussed with interest at meetings of the biological, technical, and physico-mathematical seminars of the USSR Academy of Sciences Institute of Information Transmission Problems and before other audiences.

The present book makes it possible for a large circle of specialists, graduate students and upperclass undergraduates in technical physical and theoretical biological specialties to become acquainted with interesting current research on theoretical neurophysiology.

Associate Member of the USSR
Academy of Sciences
V. I. Suforov

Introduction

As is known, the current level of understanding of the physical and chemical mechanisms of heredity and biosynthesis has become possible thanks in particular to the greatest theoretical-experimental (Mendel) and experimental (Watson, Crick, Gamov and others) discoveries. Now some progress has been noted in another area of fundamental biological problems in the field of neural activity mechanisms.

At the present time English investigators G. Brindley and D. Marr have obtained theoretical results which shed light on the principles of the work of the central nervous structures, particularly the cerebellum. From these works it has become clear in general outline how memory might be organized in animals and man. Here current theory draws on the store of knowledge gained from the achievements in neurophysiology over the last 100 years: I. Pavlov's analysis of conditioned reflexes, (Ramon-i-Kakhalya)'s neural network, Sherrington's, Eccles', Katz' and Hodgkin's accomplishments in the field of the physiology of the processes of stimulation. The theoretical accomplishments of predecessors also laid the groundwork for this theory: (Rozenblat)'s perceptron, Hebb and (Leski)'s neural ensemble, (Shennon)'s information theory, (Gabor)'s holography and many others.

This book describes the basic accomplishments and basic problems of the given science in order to attract specialists of different fields to this work. Since the scope of this book and the author's resources are very limited, this account is extremely compressed in place , and the reader is assumed to be independently familiar with the problems touched upon. Here it is undoubtedly necessary to present the author's own works in the given field in greater detail. That the problem is great and the creation of fundamental guiding principles is a thing of the future can only be partial justification of the book's possible deficiencies.

The first three chapters are basically review. Here the author tried not to repeat well known things, unless they in some way seemed to him to be especially important and conversely tried to direct attention to questions usually analyzed in less detail. To a significant degree, the fourth chapter is based on the author's earlier published works (Dunin-Barkovskiy, 1967, 1970, 1971).

In Chapter Five classic information theory and the bases of holography are presented somewhat differently than is usually accepted. Chapter six is one of the central chapters of the book. Here the so-called operational theory of the cerebellum, which was started by the works of Brindley (1964), Marr (1969), Blomfield and Marr (1970), is analyzed in detail. In the seventh chapter an attempt is made to systematize the basic results of theoretical analysis of neural systems. Chapter eight is devoted to the problems of the boundary between neurophysiology and artificial intelligence technologies.

The book is intended for specialists in theoretical neurophysiology and those who seriously want to study the questions touched upon. The fullest and most successfull coverage of the basic questions of contemporary science may be found in Griffith's monograph (Griffith, 1971). For work in the given field, physicists unfamiliar with the subject may begin reading with the chapters of Feyman's lectures on physics (Feyman et al., 1977, Vol 3, chs 35, 36) devoted to the physiology of vision and the books of P. G. Kostyuk (1977a) and D. (Vuldridzh) (1965). It is also extremely useful to become acquainted with biochemistry through G. Watson's (1967) or A. (Lenindzher)'s (2974) books and with neurophysiology through G. (Som'en)'s (1975). It is useful for biologists to acquaint themselves at the outset with (Eshbl)'s (1958) and M. Arbib's (1968) books.

The author has been lucky in having among his teachers and colleagues M. L. Tsetlin, F. V. Severin, M. M. Bongard, and S. V. Fomin. Contact with these brilliant scientists, untimely deceased, has greatly influenced the contents of this book.

Everything written was most fully discussed with A. N. Chetayev and L. M. Chaylakhyan, the scientific editors of the book. This book would not have been written without the help of A. Ya. Dunina-Barkhovskaya and the constant attention of L. V. Dunin-Barkovskiy.

The author gives thanks to V. I. Siforov for the foreword and to many friends and colleagues for scientific discussions and support.

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TABLE OF CONTENTS OF BOOK 'PHARMACOLOGY OF SHORT-TERM MEMORY'

Moscow FARMAKOLOGIYA KRATKOSROCHNOY PAMYATI (Pharmacology of Short-Term Memory) in Russian 1978 signed to press 27 Mar 79 p 2, 231-232

[Annotation and table of contents from book by Yu. S. Borodkin and V. A. Krauz, Meditsina, 5,000 copies, 232 pages]

[Text] The monograph describes mechanisms and neurophysiological processes of short-term memory, functional organization of various systems and cerebral structures in the control processes of the short-term memory and the significance of the synaptic function modification when effected by cholino-, adreno- and serotoninergic drugs as related to short-term memory.

Most of the book is devoted to the description of the neuropharmacological study of systematic organization of control processes of short-term memory using modern electrophysiological methods and correlative and factorial analysis. The basic principles of the neurodynamics of excitability in various cerebral systems and structures have been established by experiment--electrical stimulation of these structures and systems improves or impairs formation of memory. For the first time, effects of biologically active substances on short-term memory have been determined; these include derivatives of etimizol, synthesized in the Department of Pharmacology, Institute of Experimental Medicine of the USSR Academy of Medical Sciences. Neurophysiological and biochemical relationships of cerebral systems in memory processes, as well as theoretical propositions and the hypotheses concerning the intimate nature of engram formation of both short-term and long-term memory, are discussed.

The book is intended for pharmacologists, neuropathologists, psychiatrists and neurophysiologists.

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